



11 Publication number : **0 680 209 A2**

12

EUROPEAN PATENT APPLICATION

21 Application number : **95302710.9**

51 Int. Cl.⁶ : **H04N 5/91**

22 Date of filing : **24.04.95**

30 Priority : **28.04.94 JP 91393/94**

43 Date of publication of application :
02.11.95 Bulletin 95/44

84 Designated Contracting States :
DE FR GB IT NL

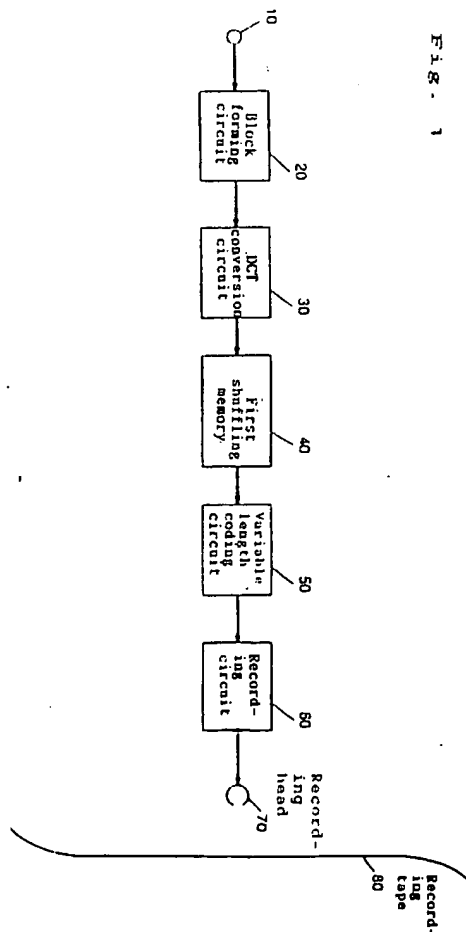
71 Applicant : **MATSUSHITA ELECTRIC
INDUSTRIAL CO., LTD.**
1006, Oaza Kadoma
Kadoma-shi, Osaka-fu, 571 (JP)

72 Inventor : **Miyashita, Mitsuhiro**
16-2 Takaginishimachi
Nishinomiyashi, Hyogo-ken 663 (JP)
Inventor : **Bannai, Tatsushi**
Kitanoda 389-12
Sakai-shi, Osaka-fu 588 (JP)

74 Representative : **Crawford, Andrew Birkby et al**
A.A. THORNTON & CO.
Northumberland House
303-306 High Holborn
London WC1V 7LE (GB)

54 **Video image coding and recording apparatus and video image coding, recording and reproducing apparatus.**

57 Coefficient data in two coding blocks which overlap on a video screen are recorded in distant regions on a recording medium so that each of the distant regions is not adjacent to each other, and error detected coefficient data during reproducing are corrected by using a fact that overlapped pixels are equal between the two coding blocks.



EP 0 680 209 A2

BACKGROUND OF THE INVENTION:

1. Field of the Invention:

5 The present invention relates to a video image coding and recording apparatus and a video image coding, recording and reproducing apparatus used for compression encoding a video signal to a coded bit stream, and also to a method of arranging the compression codes on a recording medium, and further to an error correction of reproduced signals.

10 2. Description of Prior Art:

In recent years, with a development of a digital signal processing technique, various digital apparatuses have been developed. Recently, there has been proposed to develop a more compact size digital video recorder by recording digital video signals by compression encoding. As a method for compression encoding digital video signals, recently it has become popular to adopt a discrete cosine transformation (DCT) which is one of frequency conversion of the digital video signals into coding blocks such as JPEG (Joint Photographic Coding Experts Group) or MPEG (Moving Picture Coding Experts Group). According to the method, a digital video signal is divided into the coding blocks, the coding blocks are discrete cosine transformed to obtain coefficient data, and the coefficient data are compressed by variable length coding.

20 However, in a video image coding, recording and reproducing apparatus using the method as described above, when an error occurs in the data according to the recording and reproducing, it becomes impossible to decode variable length codes at and after an error occurring point. Further, even if a discontinued point of the variable length codes is detected and variable length decodes are refreshed by a refreshing code or the like, the variable length codes cannot be decoded for a section from the error occurring point to a refreshment.

25 In a case as above, video images show lacks in several coding blocks on a video screen and such lacks extend over several video screens. This has been a large problem in the compression encoding for the video image coding, recording and reproducing apparatus.

SUMMARY OF THE INVENTION:

30 An object of the present invention is to provide a video image coding and recording apparatus in which, in recording and reproducing by compression coding the digital video signals, no lack occurs in several coding blocks on the video screen even if an error occurs, and to provide a video image coding, recording and reproducing apparatus in which error corrects the coefficient data lost by occurrence of the error on recording or reproducing.

In order to attain the above object, the present invention provides a video image coding and recording apparatus comprising:

means for dividing a digital video signal into a plurality of coding blocks each containing a plurality of pixel data;

40 means for orthogonally transforming the digital video signal in each of the coding blocks into coefficient data to form new block each having one of the coefficient data; and

means for recording the new blocks in distant regions on a recording medium so that each of the distant region is not adjacent to each other.

45 Further, the present invention provides a video image coding, recording and reproducing apparatus comprising:

means for dividing a digital video signal into a plurality of coding blocks each containing a plurality of pixel data, the coding block comprising a first coding data and a second coding data;

50 means for orthogonally transforming the digital video signal in each of the coding blocks into coefficient data to form new block each having one of the coefficient data, the coefficient data comprising a first coefficient data which is in the first coding block and has an error and a second coefficient data which is in the second coding block and has no error;

means for recording the new blocks in distant regions on a recording medium so that each of the distant region is not adjacent to each other;

55 means for reproducing the new block from the recording medium;

means for detecting whether or not the coefficient data have the error;

means for correcting the first coefficient data by using the second coefficient data to obtain error corrected coefficient data; and

means for orthogonally transforming the error corrected coefficient data to obtain a reproduced digital

video signal.

By constitutions as above, in a case that the error occur, prevention can be made from a loss of all the coefficient data in the coding block and a lack of several coding blocks during reproducing. Furthermore, by error correcting by using the coefficient data of the adjacent coding blocks having high pixel correlations, stability of a reproduced video image can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS:

Fig. 1 shows a block diagram of a video image coding and recording apparatus in a first embodiment of the present invention.

Fig. 2 shows a conceptual diagram showing regions on a recording tape.

Fig. 3 shows a block diagram of a video image coding, recording and reproducing apparatus in a second embodiment of the present invention.

Fig. 4 shows a conceptual diagram showing coefficient data of coding blocks.

Fig. 5 shows a block diagram of a video image coding, recording and reproducing apparatus in a fourth embodiment of the present invention.

Fig. 6 shows a conceptual diagram showing overlapping coded blocks;

Fig. 7 shows a block diagram of a video image coding, recording and reproducing apparatus in a fifth embodiment of the present invention.

Fig. 8 shows a first conceptual diagram showing divided groups of a coding block.

Fig. 9 shows a second conceptual diagram showing divided groups of the coding block.

Fig. 10 shows a third conceptual diagram showing divided groups of the coding blocks.

Fig. 11 shows another conceptual diagram showing divided groups of the coding blocks.

DESCRIPTION OF PREFERRED EMBODIMENTS:

Hereinafter, a first embodiment of the present invention will be explained with reference to the drawings. Fig. 1 shows a block diagram of a video image coding and recording apparatus of the first embodiment.

In Fig. 1, reference numeral 10 denotes an input terminal of a digital video signal, reference numeral 20 denotes a block forming circuit, reference numeral 30 denotes a DCT conversion circuit, reference numeral 40 denotes a first shuffling memory, reference numeral 50 denotes a variable length coding circuit, reference numeral 60 denotes a recording circuit, reference numeral 70 denotes a recording head, and reference numeral 80 denotes a recording tape.

With respect to the video image coding and recording apparatus constituted as above, an operation of the video image coding and recording apparatus is explained below.

To the input terminal 10, a digital video signal is supplied, and is divided into 4×4 coding blocks in the block forming circuit 20. An output of the block forming circuit 20 is frequency converted in each of the coding blocks by the DCT conversion circuit 30, and is stored as the coefficient data in the first shuffling memory 40. The variable length coding circuit 50 variable length codes the coefficient data outputted from the first shuffling memory 40 according to a predetermined shuffling rule.

The predetermined shuffling rule is to allow at least that the coefficient data in a same coding block are present by mixture with the coefficient data in other coding blocks, and that the coefficient data in adjacent coding blocks on a video screen, or, the coefficient data in a coding block constituting a same region on the video screen and belonging to different fields may be recorded in distant regions on the recording tape 80 as in circle marks shown in Fig. 2 by shuffling the coefficient data.

The coefficient data which has been variable length coding after shuffling as above are added to an error correcting code and subjected to channel coding in the recording circuit 60, and are supplied to the recording head 70 through a recording amplifier. The recording head 70 records the coefficient data on the recording tape 80.

The shuffling as above is explained by using a third conceptual diagram as shown in Fig. 10. In Fig. 10, (a) shows the four coding blocks A, B, C and D which are adjacent to one another in horizontal and vertical directions on the video screen. In Fig. 10, (b) shows the 16 coefficient data representing outputs of the DCT conversion circuit 30, or outputs of the four coding blocks A, B, C and D in alphabetical capital letters. In Fig. 10, (c) shows that the coefficient data from the four coding blocks A, B, C and D are present by mixture to constitute the new coding blocks W, X, Y and Z. The new coding blocks W, X, Y and Z are respectively variable length coded, and variable length codes respectively corresponding to the new coding blocks are recorded in the distant regions on the recording tape.

As described above, according to the first embodiment, by recording the coefficient data in the coding block

in the distant regions on the recording tape, even in a case that an error occurs during recording or reproducing, the coefficient data which become impossible to be decoded by the error are present in a specific coding block, in adjacent regions on the video screen, or in the different fields, and are not concentrated on the same region on the video screen. Accordingly, it is possible to solve the significant problems such as lack of specific regions of an image on a reproduced screen, or the continuous periodical lack of images in the same region.

In case of a use of a one dimension Huffman coding or the like which gives one variable length code in each of the coefficient data, it is apparent that the coding efficiency does not deteriorate even when the shuffling of the coefficient data is carried out as explained above.

Further, in case of using a two dimension Huffman coding or the like which variable length codes by combining a number of the coefficient data of continual zeros with an amplitude of the coefficient data of succeeding non-zeros, it is effective to variable length code by reading out the coefficient data corresponding to a low band conversion degree in the coding block from the first shuffling memory 40 by shuffling as described above, and by continuously reading out the coefficient data corresponding to a high band conversion degree which has good possibility for the continual zeros in the coding block.

In view of a constitution as described above, degradation of coding efficiency can be prevented. In this case, when an error has occurred during the recording or reproducing, there is a possibility for all the coefficient data corresponding to the high band conversion degree to be lost in the coding block. However, since the coefficient data corresponding to the high band conversion degree have small energy and the visual sensitivity to the coefficient data is low, no large deterioration of quality of the image should result.

Next, a second embodiment of the present invention will be described with reference to the drawings. Fig. 3 shows a block diagram of a video image coding, recording and reproducing apparatus according to the second embodiment. With respect to the same elements as those of the first embodiment, same reference numerals as used in the first embodiment are assigned and detailed explanation is omitted.

In Fig. 3, reference numeral 42 denotes a second shuffling memory, reference numeral 90 denotes a reproducing head, reference numeral 100 denotes a reproducing circuit, reference numeral 110 denotes a variable length decoding circuit, reference numeral 120 denotes a first deshuffling memory, reference numeral 130 denotes a first error correction circuit, reference numeral 140 denotes an inverse DCT conversion circuit, reference numeral 150 denotes a block decomposition circuit, and reference numeral 1650 denotes an output terminal of the digital video signal.

With respect to the video image coding, recording and reproducing apparatus constituted as above, an operation thereof is explained below.

While a circuit constitution in recording of the second embodiment is almost the same as that of the first embodiment shown in Fig. 1, a difference therebetween is a shuffling rule in the shuffling memory allowing that the coefficient data in a same conversion degree in the adjacent coding blocks on the video screen or the coefficient data in the same conversion degree of the coding block belonging to the different fields and constituting the same region on the video screen are to be recorded in the distant regions on the recording tape 80.

The shuffling as above is explained with another conceptual diagram shown in Fig. 11. In Fig. 11, (a) shows nine coding blocks A, B, C, D, E, F, G, H and I which are adjacent in the horizontal and vertical directions on the video screen. In Fig. 11, (b) shows the outputs of the DCT conversion circuit 30, or outputs of the nine coding blocks in 16 coefficient data shown in alphabetical capital letters. In Fig. 11, (c) shows that the coefficient data from the nine coding blocks are present by mixture to constitute the new coding blocks R, S, T, U, V, W, X, Y and Z. The new coding blocks R, S, T, U, V, W, X, Y and Z are respectively variable length coding, and the variable length codes respectively corresponding to the new coding blocks are recorded in the distant regions on the recording tape.

Next, a reproducing operation for reproducing the coefficient data recorded by a recording operation as above is explained.

The reproducing head 90 supplies a reproducing output from the recording tape 80 to the reproduction circuit 100. The reproduction circuit 100 demodulates and error corrects the reproducing output, and supplies reproduced variable length coded coefficient data and an error correcting error flag showing a result of the error correcting the reproducing output to the variable length decoding circuit 110. The variable length decoding circuit 110 variable length decodes the reproduced variable length coded coefficient data, and outputs, along with the coefficient data, a decoding error flag showing whether the reproduced variable length coded coefficient data are variable length decoded correctly or not, to the first deshuffling memory 120.

A generation of the decoding error flag is carried out by such steps as to output the decoding error flag to the coefficient data to be decoded in a section from an error generation point shown by the error correction error flag to refreshing a variable length decode by a refreshing code or the like, or to output the decoding error flag in a case that a predetermined number of the coefficient data is not carried out in the section in which

the predetermined number of the coefficient data should be decoded.

The first error correction circuit 130 reads out the coefficient data in the coding blocks which constitute the same region on the video screen and the decoding error flag corresponding to each of the reproduced variable length coded coefficient data from the first deshuffling memory 120, and corrects the reproduced variable length coded coefficient data on which an error has been detected.

The correction of the reproduced variable length coded coefficient data is explained below. When recording, the coefficient data in the same conversion degree in the adjacent coding blocks on the video screen or the coefficient data in the same conversion degree of the coding block belonging to the different fields and constituting the same region on the video screen are recorded in the distant regions on the recording tape 80. Accordingly, the coefficient data which are in the same conversion degree as error detected coefficient data in the coding block on the video screen adjacent to the coding block which includes the error-detected coefficient data are correctly reproduced, so that the error detected coefficient data can be corrected as an average value of error-free coefficient data on the same conversion degree.

For example, explanation is given on the case where the coding blocks T, W and Z have errors in Fig. 11. Outputs of the first deshuffling memory 120 are shown in (d) of Fig. 11 in coding blocks A', B', C', D', E', F', G', H' and I'. The coefficient data counted as errors and lost are shown as U. In the coding block E', the coefficient data E00, E10, E20, and E30 are lost, but the coefficient data in the same conversion degree are correctly reproduced in the adjacent coding blocks (coding blocks B', D', F' and H'). Therefore, by obtaining an average value of B00, D00, F00 and H00, and substituting the average value into E00, it becomes possible to make an error correction.

In general, as the coding blocks situated spatially in the vicinity have high correlations, there are correlations in the coefficient data in the adjacent coding blocks. Therefore, by adjusting errors by the average value of the error-free coefficient data of the adjacent coding block, reproduced images that give no visual obstacle can be obtained.

Further, the coefficient data in the same conversion degree in the coding block constituting the same region on the video screen as the coding block including the coefficient data in which an error has been detected and belonging to the different field is also correctly reproduced. Therefore, the coefficient data in which the error has been detected can be replaced by the error-free coefficient data in the same conversion degree as described above and corrected. In the video signal, the time-based correlations in the same region on the video screen are high. Accordingly, by error correcting by replacing the coefficient data in which the error has been detected by the error-free coefficient data of one field preceding order, visually obstacle-free reproduced images can be obtained.

Further, the error correction can be carried out adaptively in the adjacent coding blocks or between the fields.

The coefficient data in which the error corrections as explained above have been made are converted to the pixel data by the inverse DCT conversion circuit 140 and supplied to the block decomposing circuit 150. The block decomposing circuit 150 converts the pixel data divided into the coding blocks to the digital video signals, and outputs- to the output terminal 160.

As described above, according to the second embodiment, when recording, the coefficient data in the same conversion degree in the adjacent coding blocks on the video screen or the coefficient data in the same conversion degree in the coding block constituting the same region on the video screen and belonging to the different fields are recorded in the distant regions on recording medium, and when reproducing, the average value of the plural coefficient data in the same conversion degree as the error detected coefficient data in the coding block on the video screen adjacent to the coding block including the error-detected coefficient data or the coefficient data in the same conversion degree in the coding block constituting the same region on the video screen as the coding block including the coefficient data in which an error has been detected and belonging to the different field replace the coefficient data which the error is detected and correct the error. By this constitution, if the error occurs, it does not occur for the coefficient data on the same conversion degree in the adjacent coding blocks or between the continual coding blocks in the different fields to be lost simultaneously, and there is less possibility for simultaneous loss of the plural coefficient data in the same coding block. Accordingly, it is possible to error correct only the coefficient data in which the error is detected in the coding block with the adjacent coding blocks or with the different fields by utilizing the correlation of the coefficient data of the same conversion degree in the coding block of the same region, so that the reproduced images free of visual obstacle can be obtained.

Next, a third embodiment of the present invention will be described. The constitution of the video image coding, recording and reproducing apparatus of the third embodiment is the same as the constitution of the video image coding, recording and reproducing apparatus of the second embodiment shown in Fig. 3. But an error correcting method is different. A following description refers to the error correcting method only. The error

correcting method of the third embodiment is to correct an error by using pixel correlation at a boundary of the adjacent coding blocks on the video screen. Hereinafter, description is made on the error correcting method using the pixel correlation.

In general, the correlation between the adjacent pixels on the video screen is large, and the pixel correlation at the boundary between the adjacent coding blocks is also large. However, in case that the coefficient data in the coding block has been lost by error, if the lost coefficient data is taken as zero and the coding block is decoded to the pixel data, then the pixels at the boundary between the adjacent coding blocks have smaller correlations. Such a change in the pixel correlations is caused by the fact that the coefficient data to be originally reproduced has become impossible to be reproduced by the error, and the coefficient data has been replaced by zeros.

In Fig. 4, in two coding blocks adjacent to each other in horizontal direction (coding block A and coding block B), when a coefficient data A11 in the coding block A has been lost and remaining coefficient data in the coding block A and coefficient data in the coding block B are reproduced correctly, The coefficient data A11 can be subjected to error correction by using the following expression:

$$A_{11} = \frac{1}{d_{13}} ((B_{10} B_{11} B_{12} B_{13}) d_0 - (A_{10} 0 A_{12} A_{13}) d_3) \quad (1)$$

Hereinafter, explanation is given on the derivation of the expression (1). A relative equation between a pixel data a_{ij} of the coding block A and the coefficient data A_{ij} obtained by DCT conversion thereof is given by the following expression:

$$\begin{pmatrix} a_{00} & a_{01} & a_{02} & a_{03} \\ a_{10} & a_{11} & a_{12} & a_{13} \\ a_{20} & a_{21} & a_{22} & a_{23} \\ a_{30} & a_{31} & a_{32} & a_{33} \end{pmatrix} = D^T \begin{pmatrix} A_{00} & A_{01} & A_{02} & A_{03} \\ A_{10} & A_{11} & A_{12} & A_{13} \\ A_{20} & A_{21} & A_{22} & A_{23} \\ A_{30} & A_{31} & A_{32} & A_{33} \end{pmatrix} D \quad (2)$$

Similarly, the relative expression between the pixel data b_{ij} of the coding block B and the coefficient data B_{ij} obtained by DCT conversion thereof is given by the following expression:

$$\begin{pmatrix} b_{00} & b_{01} & b_{02} & b_{03} \\ b_{10} & b_{11} & b_{12} & b_{13} \\ b_{20} & b_{21} & b_{22} & b_{23} \\ b_{30} & b_{31} & b_{32} & b_{33} \end{pmatrix} = D^T \begin{pmatrix} B_{00} & B_{01} & B_{02} & B_{03} \\ B_{10} & B_{11} & B_{12} & B_{13} \\ B_{20} & B_{21} & B_{22} & B_{23} \\ B_{30} & B_{31} & B_{32} & B_{33} \end{pmatrix} D \quad (3)$$

Here, a_{ij} , b_{ij} , A_{ij} , and B_{ij} are respectively elements of a matrix of 4×4 .

D is a matrix representing the conversion basis of the DCT conversion of 4×4 , as shown below:

$$D = \begin{pmatrix} d_{00} & d_{01} & d_{02} & d_{03} \\ d_{10} & d_{11} & d_{12} & d_{13} \\ d_{20} & d_{21} & d_{22} & d_{23} \\ d_{30} & d_{31} & d_{32} & d_{33} \end{pmatrix} = \begin{pmatrix} d_0 & d_1 & d_2 & d_3 \end{pmatrix} \quad (4)$$

The boundary pixels of the coding block A and the coding block B are respectively expressed as:

$$\begin{pmatrix} a_{03} \\ a_{13} \\ a_{23} \\ a_{33} \end{pmatrix} = D^T \begin{pmatrix} A_{00} & A_{01} & A_{02} & A_{03} \\ A_{10} & A_{11} & A_{12} & A_{13} \\ A_{20} & A_{21} & A_{22} & A_{23} \\ A_{30} & A_{31} & A_{32} & A_{33} \end{pmatrix} d_3 \quad (5)$$

$$\begin{pmatrix} b_{00} \\ b_{10} \\ b_{20} \\ b_{30} \end{pmatrix} = D^T \begin{pmatrix} B_{00} & B_{01} & B_{02} & B_{03} \\ B_{10} & B_{11} & B_{12} & B_{13} \\ B_{20} & B_{21} & B_{22} & B_{23} \\ B_{30} & B_{31} & B_{32} & B_{33} \end{pmatrix} d_0 \quad (6)$$

As the pixel correlation between the boundary pixels of the coding block A and the coding block B are large, it is considered that (5) and (6) are equal, so that the following equation between the coefficient data is obtained:

$$\begin{pmatrix} A_{00} & A_{01} & A_{02} & A_{03} \\ A_{10} & A_{11} & A_{12} & A_{13} \\ A_{20} & A_{21} & A_{22} & A_{23} \\ A_{30} & A_{31} & A_{32} & A_{33} \end{pmatrix} d_3 = \begin{pmatrix} B_{00} & B_{01} & B_{02} & B_{03} \\ B_{10} & B_{11} & B_{12} & B_{13} \\ B_{20} & B_{21} & B_{22} & B_{23} \\ B_{30} & B_{31} & B_{32} & B_{33} \end{pmatrix} d_0 \quad (7)$$

As the coefficient data A11 is not correctly reproduced because of the error and other coefficient data are correctly reproduced, the equation (7) is solved with a column vector which includes the coefficient data A11, which gives the following equation:

$$\begin{pmatrix} A_{01} \\ A_{11} \\ A_{21} \\ A_{31} \end{pmatrix} = \frac{1}{d_3} \left(\begin{pmatrix} B_{00} & B_{01} & B_{02} & B_{03} \\ B_{10} & B_{11} & B_{12} & B_{13} \\ B_{20} & B_{21} & B_{22} & B_{23} \\ B_{30} & B_{31} & B_{32} & B_{33} \end{pmatrix} d_0 - \begin{pmatrix} A_{00} & 0 & A_{02} & A_{03} \\ A_{10} & 0 & A_{12} & A_{13} \\ A_{20} & 0 & A_{22} & A_{23} \\ A_{30} & 0 & A_{32} & A_{33} \end{pmatrix} d_3 \right) \quad (8)$$

The equation (8) indicates that it is possible to obtain the coefficient data containing the error by utilizing the pixel correlation between the boundary pixels by making the coefficient data containing the error zero. The expression (1) to be used for the error correction is derived from the equation (8) with respect to the coefficient data A11 in which the error occurred.

According to the third embodiment as above, by using the pixel correlation between the boundary pixels of the adjacent coding blocks, stabilized reproducing images can be obtained even when the error has occurred in reproducing.

In the third embodiment the error correction has been made to the coefficient data A11 in which the error has occurred by using the pixel correlation between the boundary pixels with the coding block adjacent to the right side in the horizontal direction, but the error correction by the similar operation made on a left side in the horizontal direction or between the upper and lower coding blocks is also possible.

Further, it may be possible to obtain the coefficient data A11 lost by the error by using the coding blocks in the four directions as described above, and the error correction can be made with the average value of the coefficient data of the coding blocks in the four directions.

It is more effective that the error correction is made between the boundary pixels having adaptively strong correlation by adopting a most highly correlated coding blocks among the coding blocks in the four directions.

It is needless to say that error corrections of the other coefficient data are also possible by the same error correcting method.

5 Next, the fourth embodiment of the present invention is explained with reference to the drawings. Fig. 5 shows a block diagram of the video image coding, recording and reproducing apparatus of the fourth embodiment. The same elements as those of the second embodiment are indicated with the same reference numerals as used in the second embodiment and detailed explanation is omitted.

10 In Fig. 5, reference numeral 25 denotes an overlap block forming circuit, reference numeral 132 denotes a second error correcting circuit, and reference numeral 155 denotes an overlap block decomposing circuit.

With respect to the video image coding, recording and reproducing apparatus constituted as above, its operation is explained below.

15 To the input terminal 10, the digital video signal is supplied. The overlap block circuit 25 divides the digital video signal into the coding blocks by overlapping so that the adjacent two 4 X 4 coding blocks mutually co-possess the one pixel at the boundary on the video screen, as shown in Fig. 6, and supplies the coding block to the DCT conversion circuit 30. The DCT converted coefficient data are subjected to the coefficient shuffling, variable length coding, and recording in the same manner as in the second embodiment and recorded on the recording tape 80.

20 When reproducing, the reproduced signal from the recording tape 80 is variable length decoded in the same manner as in the second embodiment. The variable length decoding circuit 110 variable length decodes the reproduced variable length coded coefficient data and outputs the decoding error flag showing whether the reproduced variable length coded coefficient data are decoded correctly or not, along with the coefficient data, to the first deshuffling memory 120. The second error correction circuit 132 reads out from the above first deshuffling memory 120 the coefficient data corresponding to the two coded blocks overlapped on the video screen and the decoding error flag corresponding to the coefficient data, carries out error correction, and supplies the error-corrected coefficient data to the inverse DCT conversion circuit 140. The error correction between the overlapped coding blocks in the fourth embodiment is performed under the same operation as in the third embodiment.

30 The inverse DCT conversion circuit 140 converts the error corrected coefficient data to the pixel data and supplies the pixel data to the overlap block decomposing circuit 155, and the overlap block decomposing circuit 155 converts the pixel data divided into the coding blocks to the digital video signals, and outputs to the output terminal 160.

35 As described above, according to the fourth embodiment, by dividing the digital video signals into the coding blocks so that the adjacent coding blocks mutually co-possess the one pixel at the boundary on the video screen, it becomes possible to carry out error correction similar to the error correction method as explained in the third embodiment by using the boundary pixel between the adjacent coding blocks which are originally identical pixels, thereby making it possible to realize more correct error correction and to enhance rapidly the stability of the video image coding, recording and reproducing apparatus.

40 Although in the fourth embodiment no reference is made to the quantizing operation to the coefficient data, in case that the quantizing operation is not performed, it is possible to restore completely the coefficient data lost by the error, and in case that the quantizing operation is performed, some noise may occur in the restored coefficient data attributed to the quantizing noise, but such noise does not provide a significant problem. Although in the fourth embodiment only a case of overlapping in the horizontal direction is described, the present invention is not limited to it. Needless to say, similar effect can be obtained in a case of overlapping in a vertical direction.

45 Next, a fifth embodiment of the present invention is described with reference to the drawings. Fig. 7 shows a block diagram of the video image coding, recording and reproducing apparatus of the fifth embodiment. The same elements as those of the second embodiment and the third embodiment are indicated with the same reference numerals as used in the second embodiment and the third embodiment, and detailed explanation is omitted.

50 In Fig. 7, reference numeral 43 denotes a third shuffling memory, reference numeral 122 denotes a second deshuffling memory, and reference numeral 133 denotes a third error correcting circuit.

With respect to the video image coding, recording and reproducing apparatus constituted as above, its operation is explained below.

55 The digital video signal inputted from the input terminal 10 is divided in the overlap block forming circuit 25 into the coding blocks by overlapping so that the adjacent two 4 X 4 coding blocks mutually co-possess the one pixel at the boundary on the video screen, as shown in Fig. 6, and the coding blocks are supplied to the DCT conversion circuit 30. The DCT conversion circuit 30 frequency converts each of coding blocks to

obtain the coefficient data, and the third shuffling memory 43 stores the coefficient data. The third shuffling memory 43 outputs the coefficient data according to a shuffling rule. The shuffling rule allows that the coefficient data are divided into three groups of a group 0 which includes four coefficient data which are in a lowest region of horizontal frequency components, a group 1 which includes the four coefficient data adjacent to the group 0, and a group 2 which includes 8 coefficient data not included in the group 0 or the group 1, as shown in Fig. 8. Further, the shuffling rule allows that at least six groups in the two overlapped coding blocks are recorded in the distant regions on the recording tape 80.

As described above, the coefficient data are variable length coded in the variable length coding circuit 50, added to the error corrected code and subjected to channel coding in the recording circuit 60, and supplied to the recording head 70 through the recording amplifier. The recording head 70 records the coefficient data on the recording tape 80.

The reproducing head 90 supplies the reproduction output from the recording tape 80 to the reproducing circuit 100. The reproducing circuit 100 demodulates and error corrects the reproducing output, supplies reproduced variable length coded coefficient data and the error correcting error flag showing the result of the error correcting the reproducing output to the variable length decoding circuit 110. The variable length decoding circuit 110 variable length decodes the reproduced variable length coded coefficient data and outputs the decoding error flag showing whether the reproduced variable length coded coefficient data are variable length decoded correctly or not, along with the coefficient data, to the second deshuffling memory 122. The third error correction circuit 133 reads out from the second deshuffling memory 122 the coefficient data in the coding blocks which constitute the same region on the video screen and the decoding error flag corresponding to each of the reproduced variable length coded coefficient data, and corrects the reproduced variable length coded coefficient data on which the error has been detected. This correction method is basically the same as the correction method explained in the third embodiment. The error occurs in a unit of the group unit comprising a plurality of coefficient data. For example, in the two coding blocks overlapping on the video screen (the coding block A and the coding block B), when the group 0 of the coding block A is lost, the group 0 is obtained by equation (9), and when the group 1 of the coding block A is lost, the group 1 is obtained by equation (8).

$$\begin{pmatrix} A_{00} \\ A_{10} \\ A_{20} \\ A_{30} \end{pmatrix} = \frac{1}{d_3} \begin{pmatrix} D_{00} & D_{01} & B_{02} & B_{03} \\ D_{10} & B_{11} & B_{12} & B_{13} \\ D_{20} & B_{21} & B_{22} & B_{23} \\ B_{30} & B_{31} & B_{32} & B_{33} \end{pmatrix} d_0 - \begin{pmatrix} 0 & A_{01} & A_{02} & A_{03} \\ 0 & A_{11} & A_{12} & A_{13} \\ 0 & A_{21} & A_{22} & A_{23} \\ 0 & A_{31} & A_{32} & A_{33} \end{pmatrix} d_3 \quad (9)$$

A group which is lost can be similarly obtained with respect to the coding block B.

Further, when the group 2 in the coding block A or the coding block B has been lost, the error correction is made with the coefficient data included in the group 2 taken as zeros, because the energy of these coefficient data corresponding to these coefficient data is small and the visual sensitivity to these coefficient data is low, as described in the first embodiment.

Furthermore, since the six groups in the overlapped two coding blocks are recorded in the distant regions from one another on the recording tape 80, there is less possibility for plural groups to become errors simultaneously and be lost, so that the lost coefficient data can be nearly completely error corrected.

As described above, according to the fifth embodiment, the digital video signal is divided into the coding blocks so that the adjacent coding blocks on the video screen mutually co-possess the one pixel at the boundary, the coefficient data in the coding block are divided into groups, the coefficient data in each of groups having the same horizontal frequency components, the six groups included in the overlapped two coding blocks are recorded in the distant regions on the recording tape, and when correcting the error, correction is performed such that the pixels in the overlapped region become equal to each other between the overlapped two coding blocks. Accordingly, it becomes possible to correct the four lost coefficient data simultaneously, thereby making it possible to enhance the stability of the video image coding, recording and reproducing apparatus greatly.

In the fifth embodiment, in dividing the coding block into the groups, the two coefficient data in the low-band horizontal frequency components are group divided into the groups having the same horizontal frequency components. This group division is one example of a case that the plural coefficient data having no identical vertical frequency component are group divided into the groups. However, the group division as shown in Fig. 9 may be subjected to the error correction by the similar operation.

Also, in this embodiment, the coefficient data in the coding blocks overlapping in the horizontal direction on the video screen are group divided into each coefficient data having no identical vertical frequency component to correct the error in the unit of the group. but similar error correction is possible by such procedure that the coefficient data in the coding blocks overlapping in the vertical direction on the video screen are group

divided into the group of the coefficient data having no horizontal frequency component.

Further, in the fifth embodiment, in dividing the coding block into the groups, the coefficient data in the two rows corresponding to high band conversion degree are group divided into one group. This is because of the present intention to prevent lowering of the coding efficiency by variable length coding by using a two dimension Huffman code or the like in the variable length coding circuit and reading out the coefficient data to the high band conversion degree having high possibility of showing continual zeros in the coding block. If, in the variable length coding circuit, in a case of using a one dimension Huffman coding or the like or in a case of a relatively low compression ratio, group division is made by each row and error correction is made against a loss of all the coefficient data, then the reproduction image quality at the occurrence of the error can be made extremely high.

In all embodiments mentioned above, the constitution has been explained on a premise of the recording head and the reproducing head being each single, but the number of each head is not limited to one, but same effect is obtained even in a case of two or more heads. Furthermore, when two or more heads are used, even if any head has been clogged to give failure to obtain a reproducing output, it is possible to carry out error correction effectively and obtain good reproduced video images.

Besides, as a size of the coding block, explanation has been given with an example of 4 X 4 block, but the size is not limited to it. Similar error correction can be made with any of the size such as 8 x 8, 8 x 4, and the like. The frequency conversion is not limited to DCT conversion but Adamar conversion, Stant conversion, Legendre conversion, etc. may be adopted to effect similar error correction.

Claims

1. A video image coding and recording apparatus comprising:

means for dividing a digital video signal into a plurality of coding blocks each containing a plurality of pixel data;

means for orthogonally transforming the digital video signal in each of the coding blocks into coefficient data to form new block each having one of the coefficient data; and

means for recording the new blocks in distant regions on a recording medium so that each of the distant region is not adjacent to each other.

2. The video image coding and recording apparatus according to claim 1, wherein the means for recording the new block records the new blocks included in adjacent coding blocks on a video screen in the distant regions on the recording medium.

3. The video image coding and recording apparatus according to claim 1, wherein the means for recording the new block records the new blocks included in the coding blocks which belong to different fields and constitute a same region on the video screen in the distant regions on the recording medium.

4. The video image coding and recording apparatus according to claim 1, wherein the means for recording the new blocks records the new blocks which are low band conversion degrees in a same coding block in the distant regions on the recording medium.

5. A video image coding, recording and reproducing apparatus comprising:

means for dividing a digital video image signal into a plurality of coding blocks containing a plurality of pixel data, the coding blocks comprising a first coding data and a second coding data;

means for orthogonally transforming the digital video signal in each of the coding blocks into the coefficient data to form new blocks each having one of the coefficient data, the coefficient data comprising a first coefficient data which is in the first coding block and has an error and a second coefficient data which is in the second coding block and has no error;

means for recording the new blocks in distant regions on a recording medium so that each of the distant regions is not adjacent to each other;

means for reproducing the new block from the recording medium;

means for detecting whether the coefficient data have the error or not;

means for correcting the first coefficient data by using the second coefficient data to obtain error corrected coefficient data; and

means for orthogonally transforming the error corrected coefficient data to obtain a reproduced digital video signal.

6. The video image coding, recording and reproducing apparatus according to claim 5, wherein the means for correcting the first coefficient data corrects the first coefficient data by using the second coefficient data which is in a same conversion degree of an adjacent coding block to the second coding block, or using another coefficient data on which no error has been detected, which belongs to a different field and constitutes a same region and which are in the same conversion degree of the coding block on which the error has been detected.
7. The video image coding, recording and reproducing apparatus according to claim 5, wherein the means for correcting the first coefficient data corrects the first coefficient data by using a pixel correlation at a boundary between the first coding block and another coding block adjacent to the first coding block.
8. The video image coding, recording and reproducing apparatus according to claim 5, wherein the means for dividing the digital video signal divides the digital video signal into the plurality of coding blocks at least one of the new blocks in the first coding block overlaps at least one of the new block of another coding block at a boundary between the first coding block and another coding block, adjacent to the first coding block, and the means for correcting the first coefficient data corrects the first coefficient data so that overlapped new block in the first coding block are equal to overlapped new block in another coding block.
9. A video image coding, recording and reproducing apparatus comprising:
 - means for dividing a digital video image signal into a plurality of coding blocks containing a plurality of pixel data, the coding blocks comprising a first coding data and a second coding data;
 - means for orthogonally transforming the digital video signal in each of the coding block into coefficient data to form new blocks each having one of the coefficient data, the coefficient data comprising a first coefficient data which is in the first coding block and has an error and a second coefficient data which is in the second coding block and has no error;
 - means for dividing each of the coding blocks into a plurality of groups each having a plurality of the new blocks and recording the new block of each of the groups in distant regions on a recording medium so that each of the distant regions is not adjacent to each other;
 - means for reproducing the new blocks from the recording medium;
 - means for detecting whether the coefficient data have the error or not;
 - means for correcting the first coefficient data by using the second coefficient data to obtain error corrected coefficient data; and
 - means for orthogonally transforming the error corrected coefficient data to obtain a reproduced digital video signal.
10. The video image coding, recording and reproducing apparatus according to claim 9, wherein the means for dividing into each of the coding blocks divides each of the coding blocks into the groups, each of the groups having a different vertical frequency component, and the means for correcting the first coefficient data corrects the first coefficient data by using a pixel correlation at a boundary between the first coding block and another coding block adjacent to the first coding block in the horizontal direction.
11. The video image coding, recording and reproducing apparatus according to claim 9, wherein the means for dividing each of the coding blocks divides each of the coding blocks into the groups, each of the groups having a different horizontal frequency component, and the means for correcting the first coefficient data corrects the first coefficient data by using a pixel correlation at a boundary between the first coding block and another coding block adjacent to the first coding block in the vertical direction.
12. The video image coding, recording and reproducing apparatus according to claim 9, wherein the means for dividing each of the coding blocks divides each of the coding blocks into the groups in a low band frequency region in a horizontal direction, each of the groups having a different vertical frequency component, and sets each of the coding blocks into a same group in a high band frequency region in the horizontal direction, and the means for correcting the first coefficient data corrects the first coefficient data by using a pixel correlation at a boundary between the first coding block and another coding block adjacent to the first coding block in the low band frequency region in the horizontal direction, and sets the first coefficient data to be zero in the high band frequency region in the horizontal direction.
13. The video image coding, recording and reproducing apparatus according to claim 9, wherein the means for dividing each of the coding blocks divides each of the coding blocks into the groups in a low band frequency region in a horizontal direction, each of the groups having a different vertical frequency component, and sets each of the coding blocks into a same group in a high band frequency region in the horizontal direction, and the means for correcting the first coefficient data corrects the first coefficient data by using a pixel correlation at a boundary between the first coding block and another coding block adjacent to the first coding block in the low band frequency region in the horizontal direction, and sets the first coefficient data to be zero in the high band frequency region in the horizontal direction.

quency region in a vertical direction, each of the groups having a different horizontal frequency component, and sets each of the coding blocks into a same group in a high band frequency region in the vertical direction, and the means for correcting the first coefficient data corrects the first coefficient data by using a pixel correlation at a boundary between the first coding block and another coding block adjacent to the first coding block in the low band frequency region in the vertical direction, and sets the first coefficient data to be zero in the high band frequency region in the vertical direction.

14. The video image coding, recording and reproducing apparatus according to claim 9, wherein the means for recording the new blocks records the new blocks of each of the groups so that all the groups of the first coding block adjacent to the first coding block are mutually in the distant regions on the recording medium.

15. The video image coding, recording and reproducing apparatus according to claim 9, wherein the means for dividing the digital video signal divides the digital video signal into the plurality of the coding blocks so that at least one of the new blocks in the first coding block overlaps at least one of the new blocks of another coding block at a boundary between the first coding block and another coding block adjacent to the first coding block.

Fig. 1

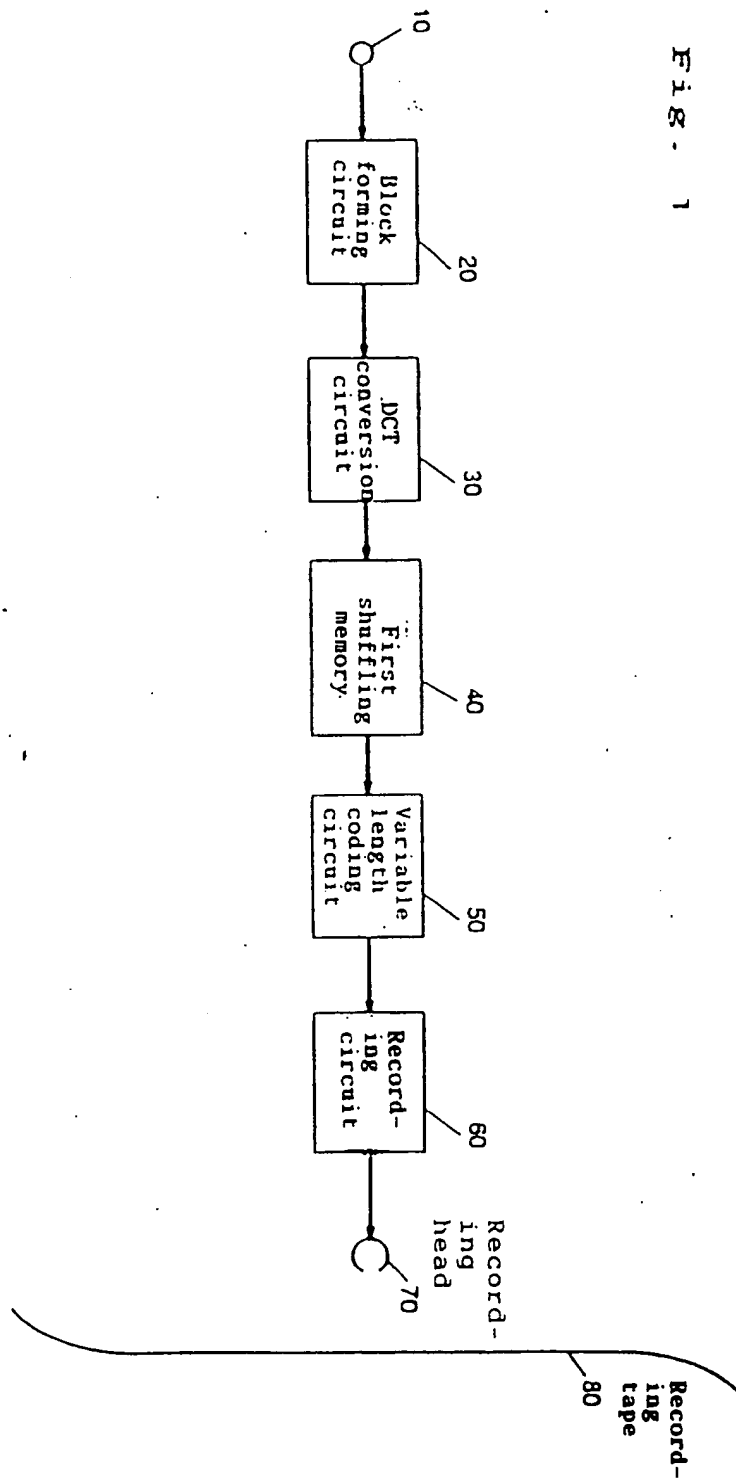


Fig. 2

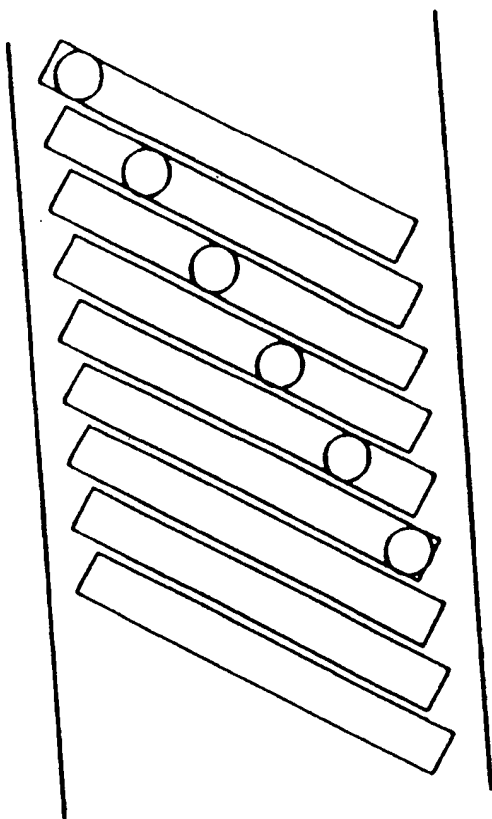


Fig. 3

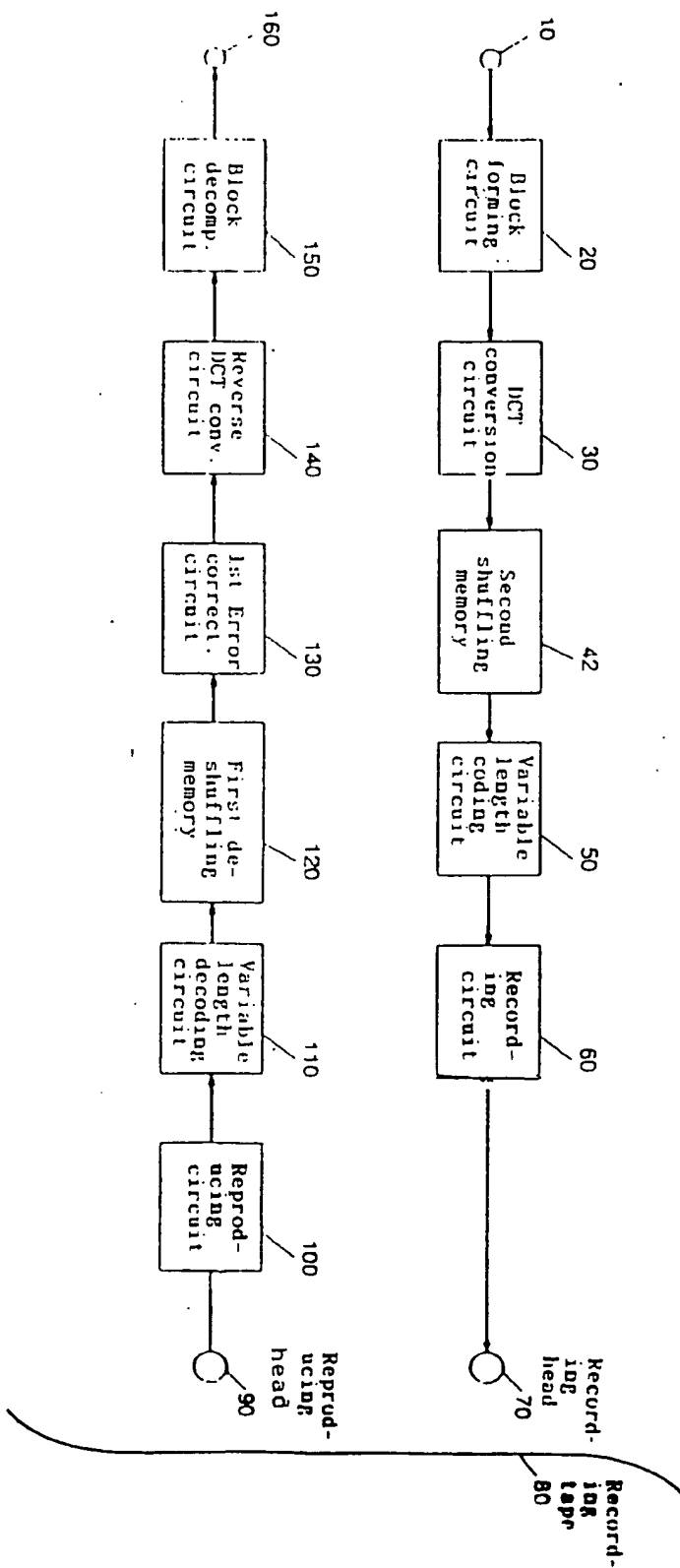


Fig. 4

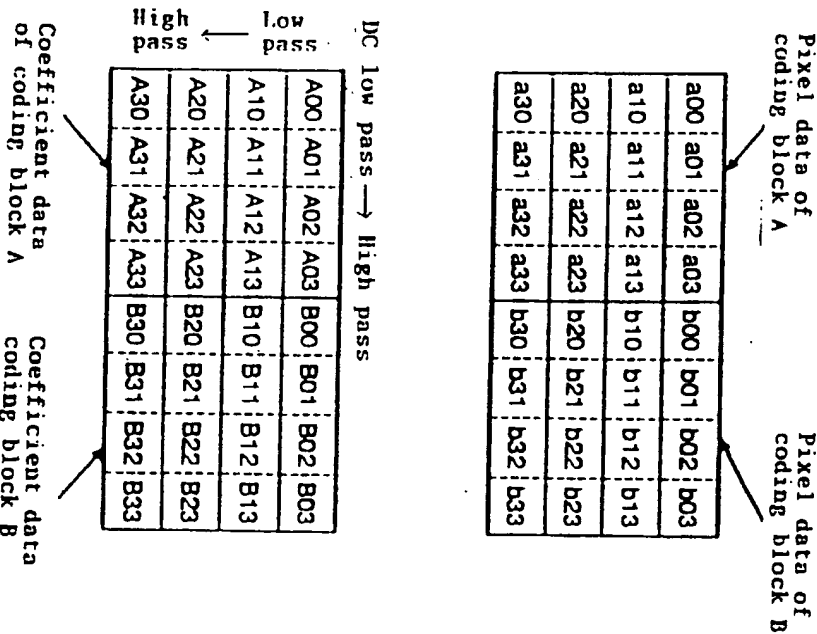


Fig. 5

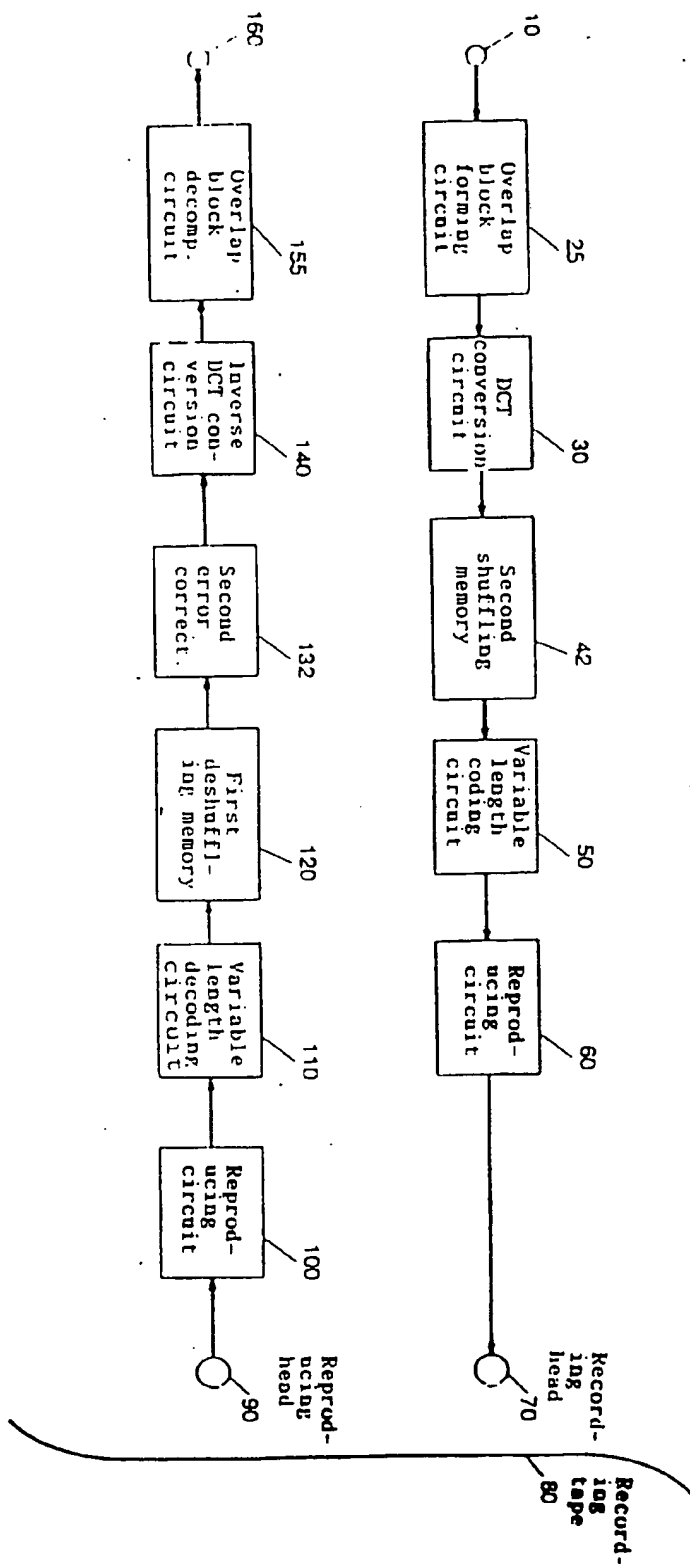


Fig. 6

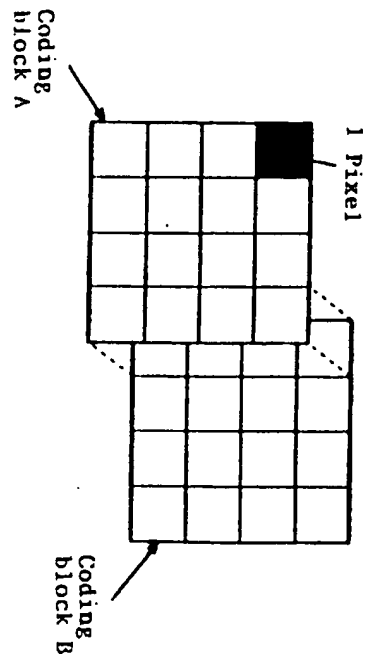


Fig. 7

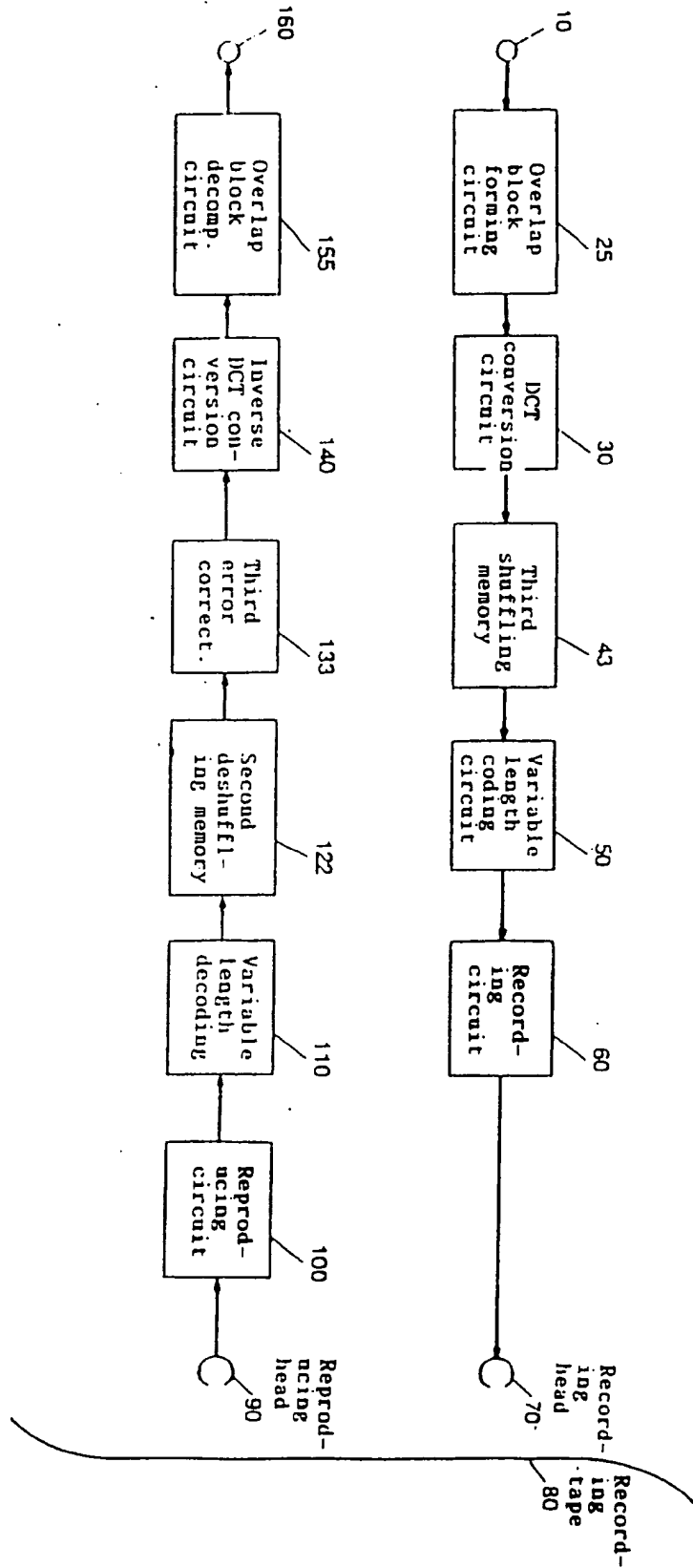


Fig. 8

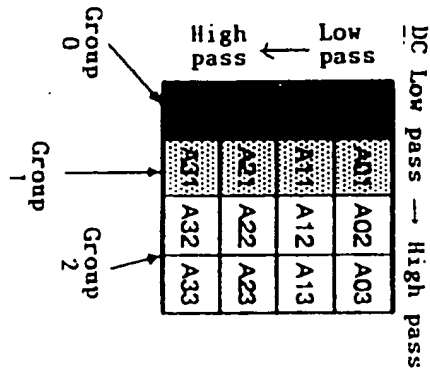


Fig. 9

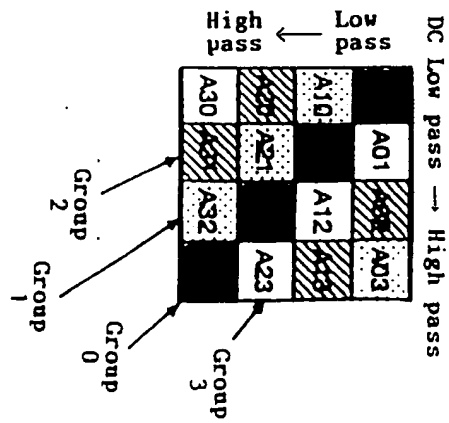


Fig.10

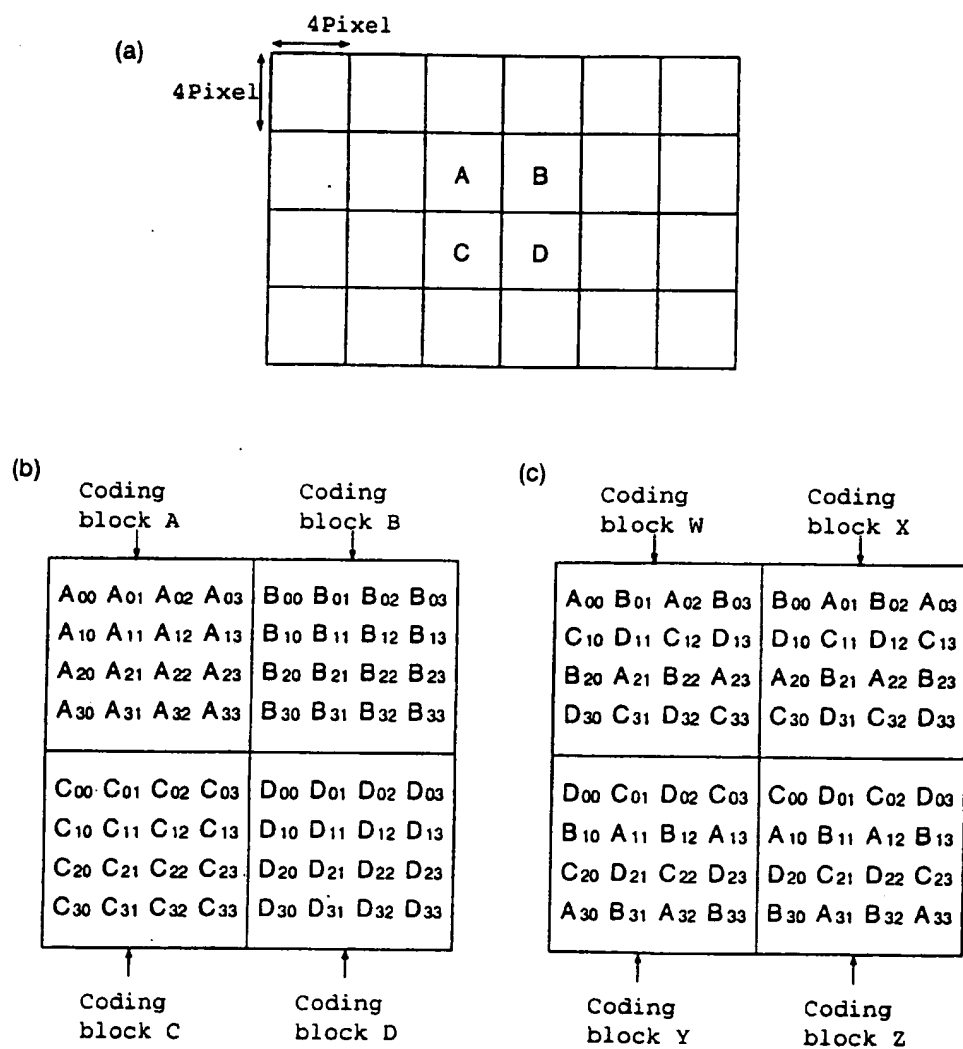
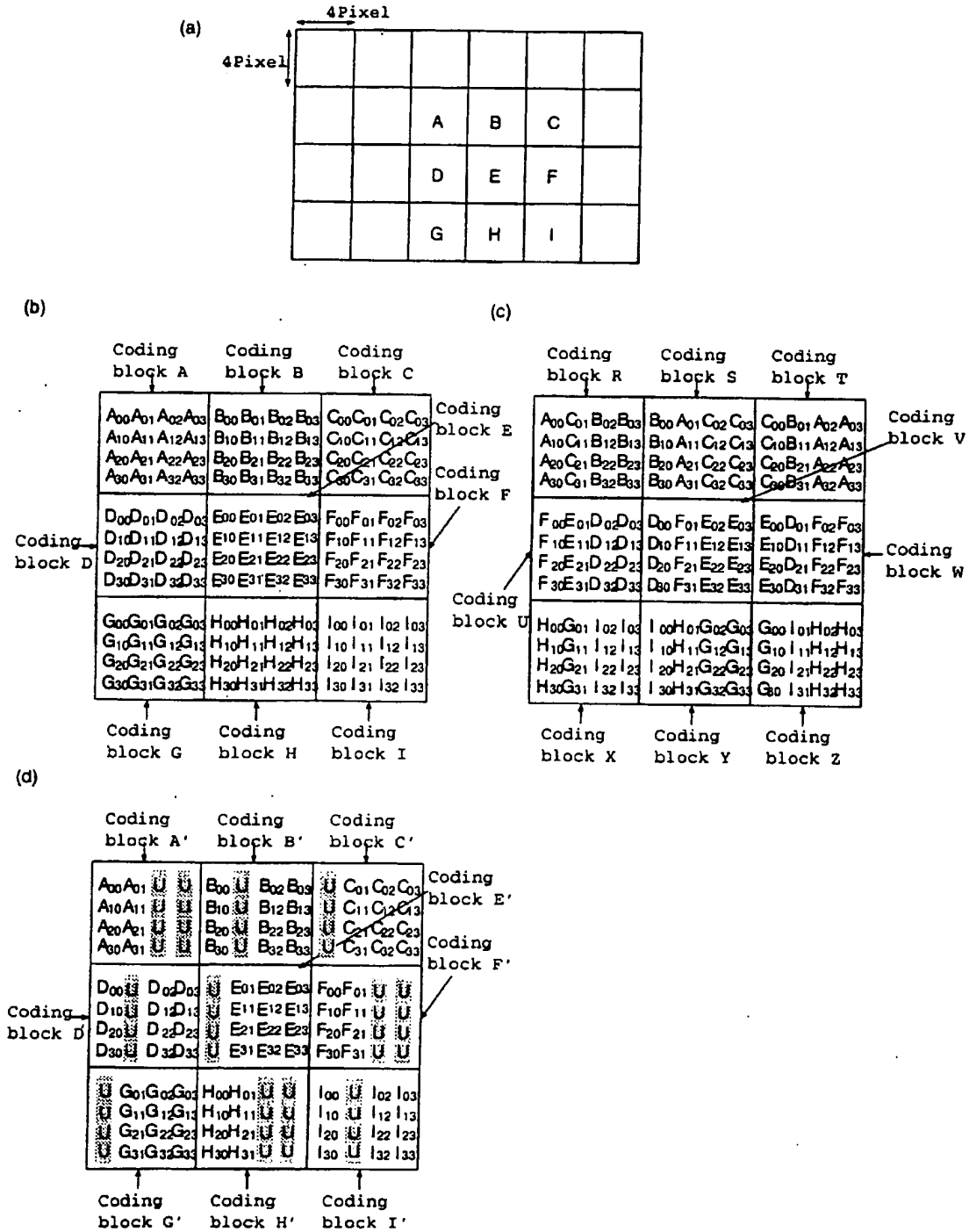


Fig.11



**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☒ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.